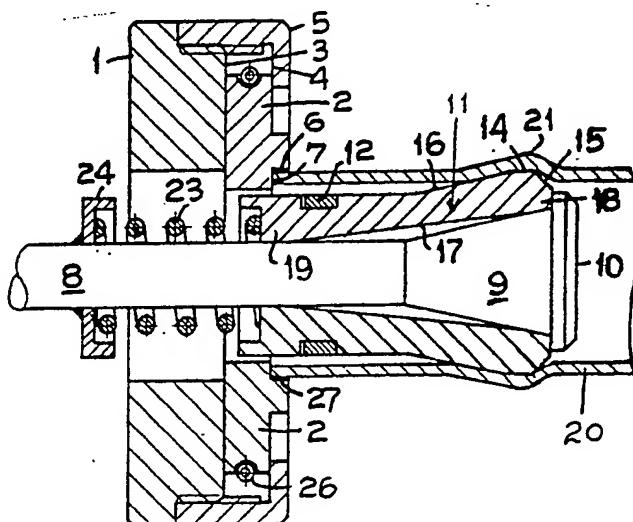




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ³ : B21D 41/02	A1	(11) International Publication Number: WO 84/00120 (43) International Publication Date: 19 January 1984 (19.01.84)
(21) International Application Number: PCT/AU83/00083 (22) International Filing Date: 27 June 1983 (27.06.83)		(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.
(31) Priority Application Number: PF 4663 (32) Priority Date: 1 July 1982 (01.07.82)		Published <i>With international search report.</i> <i>With amended claims.</i>
(33) Priority Country: AU		
(71) Applicant (<i>for all designated States except US</i>): RAST PATENT MANUFACTURERS PTY LIMITED [AU/AU]; 56 Deeds Road, North Plympton, S.A. 5037 (AU). (72) Inventor; and (75) Inventor/Applicant (<i>for US only</i>): RAST, Wlodzimierz [AU/AU]; 87 Mount Osmond Road, Mount Osmond, S.A. 5064 (AU).		
(74) Agent: COLLISON & CO; Savings Bank Building, 97 King William Street, Adelaide, S.A. 5000 (AU).		

(54) Title: TUBE EXPANDER



(57) Abstract

A tube expander of the type using an expansion die (11) comprised of segments (11A and 11B) for insertion into the end of a tube (20) to expand the diameter of the end of the tube (20) which is characterized by the insertion of the expansion die (11), which has a forward end (18), into the end of the tube (20) with the forward end (18) situated at the innermost part of the required expansion, expanding the forward end (18) of the expansion die (11) to produce a circular ridge (21) in the tube (20) and then pulling the expansion die (11) towards the end of the tube (20) to expand the tube (20) along a required length thereof, the reaction to the pulling procedure being taken by having the end of the tube (20) resting against a reaction face (7) on radially movable jaws (2) situated in a head (1), the head (1) being stationary in relation to the expand-

BEST AVAILABLE COPY

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	LI	Liechtenstein
AU	Australia	LK	Sri Lanka
BE	Belgium	LU	Luxembourg
BR	Brazil	MC	Monaco
CF	Central African Republic	MG	Madagascar
CG	Congo	MR	Mauritania
CH	Switzerland	MW	Malawi
CM	Cameroon	NL	Netherlands
DE	Germany, Federal Republic of	NO	Norway
DK	Denmark	RO	Romania
FI	Finland	SE	Sweden
FR	France	SN	Senegal
GA	Gabon	SU	Soviet Union
GB	United Kingdom	TD	Chad
HU	Hungary	TG	Togo
JP	Japan	US	United States of America
KP	Democratic People's Republic of Korea		

"TUBE EXPANDER"

This invention relates to a tube expander and in particular it relates to a tube expander which can be used to expand a portion of a tube, preferably the end, to allow joining of the ends of two coaxially placed tubes and in particular it relates to an expander which can expand tubes of hard material such as hard drawn copper but which will be usable on soft copper tubing and other materials as well.

There are on record many forms of tube expander but the most general form are those in which a series of jaws are mounted to expand radially about an axis so that when they are inserted into a tube at its end the expansion of the jaws will stretch the material of the tube to increase its end diameter by the required amount, such as generally by the thickness of the wall of the tube to allow joining of two tubes by sliding the end of one tube into the expanded end of the other tube. Such devices are open to the objection that they cannot effectively work on tubes of hard material and inevitably tend simply to split the tube rather than expand it.
See Australian Patent No. 426,882.

Another disadvantage referred to in the above Australian Patent is the area over which the jaws operate to expand the tube which requires a considerable force to be exerted on the handles of a tube expander of this form, and various attempts have been made to ease the force which must be



2.

applied, particularly those tube expanders which
are for hand use. Among the methods of lowering
the required force on the handles of these devices
is one in which the arrangement is such that the
5 jaws are moved in successive stages so that on
the first operation of the handles a partial expansion
of the tube only results and on further operation
of the handles the tube is further expanded.

Attempts have been made to reduce this pressure
10 by using an arrangement other than the normal cam
operating on a drift, but as stated earlier, even
if the required force can be exerted to expand
the tube, the system of expanding jaws does not
work with hard drawn tubing because the material
15 splits rather than uniform expansion taking place
around the perimeter of the tube. See International
Application No. PCT/AU80/00038.

Because of the problems which exist with radially
expanding jaws it has been proposed to expand a
20 tube by driving in a former such as a ball for the
required distance but this results in a problem
in holding the tube against the relatively high
force which is exerted to move the tube axially
25 as the expansion takes place, and the types of
grips which must be used to hold the tube against
axial displacement in such a case tend to damage
the wall of the tube if sufficient hold exists.
Therefore this form of apparatus has not been success-
30 ful because of the damage which occurs to the tubes
adjacent to the area, or at the area, where expansion
is taking place.



3.

The object of the present invention is to overcome the problems referred to above and to provide a tube expander which is relatively easy to operate so far as operating pressures are concerned and which will operate on harder material tubes without splitting and further will not damage the tube itself due to the need to hold it in grips against heavy axial forces applied during the expansion.

The objects are achieved according to this invention by expanding the tube over the area defined for the expansion by commencing expansion remote from the tube expander and causing expansion linearly towards the expander, the device preferably consisting of an expansion die in segmented form which can be moved into the end of a tube to the distance over which the tube is to be expanded and is then expanded outwardly to make contact with the tube and expand the tube by radial pressure at a circular area, the expansion die being then moved towards the tube expander to progressively expand the tube.

In this device the end of the tube which is being expanded is simply resting against the expander itself so that the tube need not be otherwise gripped, although guide means can be provided if required, whereby, because the tube is progressively expanded linearly towards the expander, the force required is considerably less than by some other methods and also splitting of the tube does not generally occur because of the relatively circular contact only at the area of the expansion die remote of the end of the tube. Because the pull is toward the expander the tube does not need to be firmly

4.

gripped as the expansion die pulls the tube firmly to the expander to provide the necessary reaction force.

The device can be constructed in various ways but according to a simple arrangement the expander
5 can be of a similar form to the hand operated expanders used at the present time in which a head forms part of one handle and another handle is pivoted to the head to allow manipulation of a pull rod extending through the head, the head having jaws shaped to allow a tube of the required diameter
10 to be engaged therein with faces against which the end of the tube rests, the pull rod having at its extremity a tapered portion and a flange and having, arranged to slide on the tapered portion, the expansion die which can be of segmented form by having longitudinally formed segments with the remote end of the expansion die given a fairly short radius and the die sloping back to a retaining ring for the sections of the die so that this expansion die can be pulled
15 down onto the smaller part of the tapered portion on the pull rod as the pull rod is moved forwardly to position the expansion die at the locality where the inner end of the expansion is to occur, and by then moving the pull rod back the expansion
20 die is forced outwardly as the sections of the die move on the taper to cause an annular outward expansion of the tube at this locality, but when full expansion has been reached continued pull
25 on the pull rod causes the expansion die to move along the tube which has its end against the face on the jaws of the head until the expansion has been effected linearly to the end of the tube.
30

5.

The method of expanding a selected end part of a tube comprises:

- (a) Inserting an expansion die into the tube to the further end of the area to be expanded remote from a head supporting the expansion die,
- 5 (b) engaging the end of the tube against a reaction face of the head,
- (c) causing the expansion die to expand to the diameter of the required expansion, and
- 10 (d) pulling the expanded die towards the reaction face to progressively continue the expansion to that end of the tube engaged on the reaction face.

The invention is characterised in that the expansion die is supported by a head and is arranged to be positioned in a tube through one end thereof to engage the inner surface of the tube at least remotely of the end of the tube, means being provided to expand the forward inserted end of the expansion die to effect an annular expansion of the tube at the forward end portion of the expansion die, means being also provided to pull the expansion die toward the head to progressively expand the end portion of the tube, means being provided on the head to engage the end of the tube being expanded to hold the tube against axial movement during the linear expansion action.

The tube expander according to the preferred form of this invention thus comprises a head having an aperture therethrough, a pull rod extending through the aperture, an expansion die positioned on a forward part of the pull rod, means to urge the expansion die forward on the pull rod, means to limit the forward

6.

movement of the expansion die on the pull rod, means on the pull rod to expand the expansion die when urged forward on the pull rod, means to pull back the pull rod in relation to the head, and a face on 5 the head to engage the end of a tube to be expanded.

In order however that the nature of the invention will be fully appreciated an embodiment thereof will now be described with reference to the accompanying drawings in which:

10 FIG. 1 is a perspective view of the tube expander with the pull rod retracted.

FIG. 2 is a similar view with the pull rod moved forward as when commencing a tube expansion.

15 FIG. 3 is a view of the tool as in FIG. 2 but to an enlarged scale, showing the tool sectioned on planes normal one to the other.

FIG. 4 is a plan of the expansion die, with part of the pull rod shown, the spring being section.

20 FIG. 5 is a longitudinal sectional view of the head and jaws and the expansion die mounted on the pull rod with a tube being pushed into position to be engaged by the jaws.

25 FIG. 6 is a view similar to FIG. 5 but showing the tube pushed forward and engaged in the jaws with its end against the face of the jaws and with the pull rod pushed forward into the tube to position the expansion die at the location where the expansion of the tube is to commence.

7.

FIG. 7 is again a similar view to FIGS. 5
and 6 but showing the pull rod actuated to expand
the expansion die, with the flange positioned against
the end of the expansion die in readiness to commence
a traverse along the tube, and

FIG. 8 is a similar view but showing the
expansion of the tube completed and showing the
expansion die pulled back to the position where
the tube is released from the expansion die and is
releasable from the jaws.

Referring now particularly to the drawings, the
head 1 has on it radially movable jaws 2 confined
between a face 3 of the head 1 and a face 4 of a
keeper 5 which is engaged on the head 1.

The jaws 2 have a recess 6 at their inner
ends and a reaction face 7 against which the end of a
tube to be expanded rests, this reacton face 7 being
adapted to take the axial force generated on the tube
during the operation of the expansion die and thus
forming the means for holding the tube without having
to use any form of gripping device engaging the
outside of the tube remote from the end as has been
the practice heretofore.

The pull rod 8 has at its end a tapered portion
9 and a flange 10.

The expansion die 11 consists of a first and a
second series of longitudinally divided segments 11A
and 11B grouped about the pull rod 8 and held together
by a ring 12 engaging circumferential grooves in the
segments 11A and 11B of the expansion die 11.

8.

The forward end of the expansion die 11 has an annular surface 14 which defines the expansion required at the end of the tube, a sloping surface 15 forming a lead to the annular surface 14, the surface 5 of the expansion die 11 sloping inwards from the annular surface 14 to provide an expansion lead 16.

The inner surface 17 of the expansion die is shaped so that the expansion die 11 engages the tapered portion 9 of the pull rod 8 at the forward 10 end 18 of the segments 11A and 11B of the expansion die, while the rear end 19 of the expansion die 11 rests on the pull rod 8 so that the segments 11A and 11B of the expansion die 11 can tilt to cause the forward ends 18 of the segments 11A and 11B to expand 15 outwardly under action of the tapered portion 9, while retaining the rear end 19 in contact with the pull rod 8.

The surface 14, together with the expansion lead 16, serve to expand the tube 20 when the pull 20 rod 8 is moved rearwardly from the position shown in FIG. 6 to that shown in FIG. 7, at which stage the tube has an annular expansion 21 remote from its end.

At the rear end of the expansion die 11 is a spring 23 confined between the rear end of the 25 expansion die 11 and a collar 24 which, in the illustrations, is shown as welded to the pull rod 8 but can be adjustable along the pull rod 8 by threading the pull rod and the collar 24 or by provided grub screws or the like to lock the collar 24 in position 30 on the pull rod 8 at the position where the required force of the spring 23 is achieved to urge the expansion die 11 forward.

9.

The reason for using segments 11A and 11B of different form is to ensure that the expansion die 11 will form a true circular surface which will expand the tube without draw marks caused through gaps between the segments. The segments 11A are the main segments of the device but intermediate segments 11B fit between the main segments 11A and are tapered and angled such that the segments 11A and 11B can have a certain amount of longitudinal movement between them to complete a circle at the annular surface 14 and moreover to have the edges of the segments 11A and 11B at an angle to the line of the draw to ensure that the expansion of a tube takes place in true circular form without forming fins on the inside of the expanded portion. The angular inter-engagement is on the lines 11C, that is at the annular surfaces 14.

To allow accommodation of the one group of segments 11A in relation to the other group of segments 11B the circumferential grooves in which the retaining ring 12 is accommodated are longer in the segments 11A than in the segments 11B so that when the device is pushed into a tube preparatory to expanding the end of the tube the segments can all accommodate themselves correctly in relation to the inner face of the tube, but when the initial expansion takes place which occurs because of the friction between the annular surface 14 of the segments and the inside of the tube 20 to be expanded all segments 11A and 11B will be pushed outward in the position they have assumed. When however the flange 10 on the end of the pull rod 8 contacts the end 18 of the segments 11A and the segments 11B and all segments are then moved together under control of the flange 10 which holds

10.

the expansion uniform during the draw of the expansion die 11 rearwardly in the tube to the end of the completed expansion. The grooves are designated 25.

Referring to the operation of the device, it will
5 be seen from FIG. 6 that the pull rod 8 with its
tapered portion 9 and flange 10 is encircled at
its forward portion by the segments 11A and 11B of the
expansion die 11 and these segments 11A are free to
move at the forward end 18 of the expansion die 11
10 under control of the tapered portion 9 of the pull rod
8, and when it is required to expand a tube 20, the
tube is pushed in the direction of the head 1 as shown
in FIG. 5 and because of the sloping surface 15 on the
segments 11A and 11B of the expansion die 11 will
15 cause the segments 11A and 11B of the expansion die 11
to move inward generally radially at their forward end
provided the pull rod 8 is projected forwardly a
sufficient distance to bring the end 18 of the
segments 11A and 11B of the expansion die 11 into the
20 position shown in FIG. 6.

At this stage the annular surface 14 engages the
inner face of the tube 20 and slides along the tube 20
as the pull rod 8 is advanced, the spring 23 being
compressed at this stage to ensure that contact of the
25 inside of the tube 20 by the annular surface 14 is
retained as the pull rod 8 is advanced to the position
shown in FIG. 6.

FIG. 6 shows how the end of the tube 20 is
engaged in the jaws 2 which are urged inwards by a
30 spring circlip 26 to have the shoulders 27 of the
recess 6 on the jaws 2 engage the tube 20 and to have



II.

the end of the tube 20 engage the reaction face 7 on the jaws 2 to take the thrust.

If the pull rod 8 is now pulled back in the direction of the arrow in FIG. 6, the forward ends 18 of the segments 11A and 11B of the expansion die 11 will be forced outwards as shown in FIG. 7, the flange 10 limiting the outward movement of these ends 18 of the segments 11A and 11B of the expansion die 11 to the amount of expansion required on the tube 20.

During the movement of the pull rod 8 from the position shown in FIG. 6 to the position shown in FIG. 7 the expansion die 11 does not move axially but the forward end of the expansion die segments 11A and 11B move out to expand the effective diameter of the end of the expansion die 11 forming the annular expansion 21 to give a circumferential ridge. When pull continues the expansion die 11 is moved forward with the pull rod 8 to the position shown in FIG. 8, this movement forming the expanded portion 30 required on the tube 20.

As this end of the tube 20 is expanded the jaws 2 move outward against pressure of the spring circlip 26 to still accommodate the expanded end of the tube. At this stage the tube 20 can be removed as the expanding action is complete.

The movement between the head 1 and the pull rod 8 can be obtained by any suitable actuating members such as a pair of levers 32 and 33, the lever 32 being connected to the body 29 which supports the head and the other lever 33 pivoted to the body 29 and having a connection (not shown) to the pull rod 8. In



12.

place of levers it is possible to use a hydraulic mechanism which can readily be applied between the pull rod and the head.

The form of the expansion die can of course
5 be varied and instead of it being formed of separate segments it can take the form of an expanding ring with a rounded outer perimeter, that is rounded in cross-section, the purpose of the expansion die being to move outwardly and form an outwardly pressed
10 circular ridge and to then move the expansion die axially in the tube while the end of the tube is held against the reaction face of the head to progressively linearly expand the tube.

Not only does this allow the tube to be expanded
15 with a lesser force but it avoids the splitting of the tube because the expansion takes place only at a small circular area and moves forward linearly, again operating only on a small area at any time.

The device can be made with interchangeable
20 heads to take different sizes of tube or the taper on the pull rod can be provided with adjusting means which allow the expansion die to have limited movement only on the taper of the rod such as by moving an end rim or collar axially along the pull
25 rod or alternatively the expansion die itself can be attached to means which limit its outward movement on the taper to thereby determine its starting diameter and such adjustment can be indexed to allow the tool to be used on tubes of different
30 size by appropriately positioning the control means for the position of the expansion die on the taper.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. The method of expanding a selected end part of a tube which comprises:

5 (a) Inserting an expansion die into a tube to the further end of the area to be expanded remote from a head supporting the said expansion die,

(b) engaging the end of the tube against a reaction face on the said head,

10 (c) causing the said expansion die to expand to the diameter of the required expansion, and

(d) pulling the expansion die towards the said reaction face to progressively continue the expansion to that end of the tube engaged on the said reaction face.

2. The method of claim 1 further characterised by the steps of engaging the end of the tube to be expanded in radially movable jaws on the said head, and urging the said jaws inward to engage 5 the periphery of the end of the said tube, said reaction face being formed on said jaws to engage the said end of the said tube.

3. The method of claim 1 or 2 further characterised by the steps of urging a series of segments forming the said expansion die axially on a tapered pull rod to expand the said expansion die, but 5 causing the said segments to move back against the urging means when inserting the said expansion die into the said tube whereby to cause the said segments to move forwardly in contact with the internal face of the said tube when inserting the 10 said expansion die in the said tube.



14.

4. A tube expander comprising a body having a head supporting an expansion die and having means to actuate the expansion die to expand a portion of said tube when placed over the said die characterised in that the said expansion die is supported by the said head and is arranged to be positioned in a tube through one end thereof to engage the inner surface of the said tube remotely of the said end of the tube and has an expansion lead, means to expand the forward inserted end of the said expansion die to effect an annular expansion of the tube at the forward end portion of said expansion die, means to pull the said expansion die towards the said head to progressively expand the said tube by means of the said expansion lead, and means on the said head to engage the end of the tube being expanded to hold the said tube against axial movement during the linear expansion action.

5. A tube expander according to claim 4 characterised in that the said expansion die comprises a series of segments held together at a rear end but expandable at a forward end.

6. A tube expander according to claim 5 characterised in that the said expansion die comprises two series of segments having at the forward ends inter-engaging sloping surfaces at an annular surface which engages the said tube to expand same, one said series of segments being longitudinally movable one to the other to maintain a relatively continuous annular surface.

7. A tube expander according to claim 4 characterised in that the said means to engage the end of



the tube to hold the tube against draw reaction comprises a reaction surface on radially movable
5 jaws carried on the said head.

8. A tube expander comprising a die arranged to expand an end portion of a tube by movement of the die relative to the tube and including means to actuate the die to cause the expansion of the
5 tube, characterised by

(a) an expansion die adapted to be inserted into the tube through an end of the tube to be expanded,

10 (b) a body and head supporting the said expansion die to project from the said head into the said tube,

15 (c) a reaction face on the said head to engage the end of the tube to be expanded when the said expansion die is advanced to project into the said tube,

(d) means to exert an expansion force on the said die to expand the end of the die in the said tube remote from the said reaction face,

20 (e) means to limit expansion of the expansion die when the said expansion force is exerted, and

25 (f) means to pull the expansion die toward the said head and through the end of the tube which engages the said reaction face, whereby the said die first expands the said tube at the further part of the said expansion and then progressively expands the die by axial movement to the end of the tube.

9. A tube expander according to claim 8 wherein the expansion die comprises segments having an annular surface at the forward expansion end to engage the inside surface of the tube and has a

16.

5 forward inward sloping surface and a rearward inward expansion lead extending from the said annular surface.

10. A tube expander comprising a body having a head supporting an expansion die and having means to actuate the expansion die to expand a portion of the said tube when placed over the said die
5 characterised by a pull rod extending through an aperture in the said head, an expansion die positioned over a forward portion of the said pull rod, means to urge the expansion die forward on the said pull rod, means to limit the forward movement of the
10 expansion die on the said pull rod, means on the said pull rod to expand the said expansion die when urged forward on the said pull rod, means to pull back the said pull rod in relation to the said expansion die, and a reaction face on the
15 said head to engage the end of said tube to be expanded.

11. A tube expander according to claim 10 characterised by jaws arranged about the said pull rod and supported by the said head to be radially movable thereon, means to urge the said jaws inwards,
5 a recess on each said jaw adapted to engage the end of a said tube to be expanded, the said reaction face being positioned on the said jaws within the said recess.

12. A tube expander according to claim 10 or 11 characterised by a series of segments forming the said expansion die and arranged about the said pull rod, and by a tapered portion on the forward end portion of the said pull rod expanding to the
5



10 said forward end of the said pull rod, and by a flange at the forward end of the said pull rod, said segments of the said expansion die engaging the said tapered portion at a forward end portion and the said pull rod at a rear end portion.

13. A tube expander according to claim 10 or 11 characterised by a first series of segments forming the said expansion die and arranged about the said pull rod, and a second series of segments 5 disposed between the said first series of segments, a retaining ring engaging a groove at a rear end portion in each said segment, said grooves in one said series of segments being wider to allow limited longitudinal movement of one said series of segments 10 in relation to the other said series of segments, each said segment having part of an annular surface on its end portion remote from the said retaining ring positioned to be pressed against the inner surface of the tube to be expanded, the said series of 15 segments being angled in relation to the direction of movement of the said expansion die where they contact at the said annular surface.

14. A tube expander according to claim 10 or 11 characterised in that the said means to expand the said expansion die comprise a pull rod having a forward end projectable through the said aperture 5 in the said head and tapered at its forward end portion to an increased diameter and having a flange at the said forward end, the said expansion die comprising a first series of segments arranged about the said pull rod, and a second series of 10 segments between the said first pair of segments, a retaining ring encircling the said segments at



18.

a rear end portion and engaging a groove in each
said segment to longitudinally confine the said
segments, said rear end portion of each segment
15 engaging the said pull rod, a forward portion of
each said segment engaging the said tapered portion
of said pull rod, and angled interengaging faces
on the said first and second series of segments
at an annular surface positioned to engage the
20 inside of a tube when the said expansion die is
inserted in a tube.

15. A method of expanding tubes substantially
as described and illustrated.

16. Means for expanding the ends of tubes
constructed and operating substantially as described
and illustrated.

AMENDED CLAIMS

[received by the International Bureau on 24 November 1983 (24.11.84);
original claims 1-18 replaced by new claims 1-12]

1. The system of expanding a selected end part of a tube in which an expansion die is inserted into a tube to the further end of the area to be expanded remote from a head supporting the expansion die while engaging the end of the tube to be expanded against a reaction face on the head, expanding the end of the die remote from the head by a tapered pull rod to the diameter of the required expansion and pulling the expansion die towards the reaction face to progressively continue the expansion to that end of the tube characterised by independently adjusting in a direction axial to the pull rod a first and a second set of segments forming the expansion die and spaced alternately around the pull rod and having complementary expansion faces at the said remote end including radial angular complementary faces, and causing the one series of segments to slide axially relative to the other said series to retain contact of the radially angular faces of the two series of segments to form a continuous expanding surface without gaps between the segments at the expansion area.

2. The system of Claim 1 characterised by moving the said expansion die forward in the tube by exerting pressure against the rear of the first said series of segments having the radially angular faces diverging to the remote end of the said die and moving the expansion die toward the said reaction face by engaging the outer ends of the first said series of segments, whereby the said second series of segments which has the angular faces converging accommodates by axial movement to retain the said continuous expanding surface.

3. A tube expander comprising a body having a head and an axially movable pull rod projecting therefrom, and positioned on the projecting end portion of the said pull rod an expandable die adapted to be inserted in a tube the end of which is to be expanded, and a reaction member on the said head to receive the end of the said tube during expansion, characterised in that the said expansion die has a first series of segments having diverging wedge-shaped ends and a second series of segments alternately positioned side by side and having complementary wedge-shaped ends longitudinally movable the one set of segments to the other, the said segments being inter-engaged at the wedge-shaped ends to form an annular tube-expanding portion on said expansion die variable in diameter by the position of one series of segments longitudinally in relation to the other.

4. A tube expander according to Claim 3 characterised in that the said segments are urged on to the said pull rod at a rear portion but are expandable at a forward position remote from the said head by engagement with a taper on the said pull rod but limited in expansion by a flange on the said pull rod positioned to engage the forward ends of at least one set of the said segments when the said pull rod is moved to expand the said die.

5. A tube expander according to Claim 3 characterised in that the said reaction member comprises radially movable, inwardly urged, stepped jaws carried by the said head.

6. A tube expander according to Claim 3 characterised in that the said annular tube-expanding portion has an inward sloping surface remote from the said head and a rearward inward sloping expansion head facing the said head.

7. A tube expander comprising a body and a head supporting an expansion die and having means to actuate the expansion die to expand a portion of a tube when placed over the said die, said expansion die being extendable from the said head and arranged to be positioned in a tube through one end thereof to engage the inner surface of the said tube remotely of the said end of the tube, characterised in that the said expansion die comprises two series of segments having at the ends remote from the said head interengaging surfaces which slope in relation to the longitudinal axis of the said die to form complementary wedge-shaped members, one said series of segments being longitudinally movable in relation to the other to maintain a relatively continuous annular surface, means to expand the forward end of the said expansion die to effect an annular expansion of a tube at the forward end portion of said expansion die, means to pull the said expansion die towards the said head to progressively expand the said tube by means of the said expansion die, and means on the said head to engage the end of the tube being expanded to hold the said tube against axial movement during the linear expansion action.

8. A tube expander comprising a body and a head and an axially movable pull rod projecting therefrom, and positioned on the projecting end portion of the pull rod an expandable die adapted to be inserted in a tube the end of which is to be expanded, and a reaction member on the said head to receive the end of the tube during expansion, characterised in that the said expansion die comprises a first series of segments arranged about the said pull rod, and a second series of segments positioned between the first series of segments, said segments each engaging the pull rod at their rear portion near the said head and a taper on the pull rod

22

at their forwardly projecting portion remote from the said head whereby the said die is expanded at the forward end when the said pull rod is moved rearwardly, said die having an annular tube-expanding surface at the end remote from the said head, said die having at the said tube-expanding surface interengaging sloping surfaces on the said segments generally radially positioned, and arranged in wedge form expanding toward the end of the die remote from the said head, said second series of segments being longitudinally movable in relation to the said first series of segments also having sloping surfaces but complementary to the segments of the first series, means to limit the said longitudinal movement, of one series of segments to the other, whereby the series of segments maintain a continuous expansion surface during expansion of the tube and the interengaging sloping surfaces are inclined to the direction of movement of the expansion die.

9. A tube expander according to Claim 8 characterised in that the said means to limit movement of the said segments comprise an annular groove around the said die, a ring engaging the said groove, further characterised in that the groove in the first said series of segments limits axial movement of the said first series of segments relative to the said ring, but the groove in the second series of segments is wider than the said ring to allow limited longitudinal movement of the said second series of segments, and a flange on the said pull rod to limit expansion of the said die.

10. A tube expander according to Claim 8 characterised in that the first series of segments are urged forwardly by spring means when inserting the said expansion die in a tube to be expanded, and are urged in the tube expanding traverse by a flange on the said pull rod at the end remote from the said head, and in that the said second series of segments are free to move longitudinally in relation to the said first series of segments to maintain the said complementary surfaces of one series of segments in contact with the other said series of segments.

11. A die assembly for a tube expander according to the system as defined in Claim 1 or 2 which is characterised by a pull rod projecting from a body having a head which forms the said reaction face and having at the projecting end an outward taper and a terminal flange and having on it remote from the outwardly projecting end spring means encircling the said pull rod, and disposed on the said pull rod between the said terminal flange and the said spring means an expanding die comprising first segments spaced apart around the die and having substantially radial faces at the ends adjacent the terminal end diverging outwardly to form a wedge and a second series of segments disposed between the first said series of segments and having the end portion adjacent the terminal flange arranged as a converging wedge complementary to the diverging wedge faces on the first said series, a ring surrounding the said die on an end part remote from the wedge ends engaging grooves in said segments, with the segments of the first said series longitudinally confined in relation to the said ring and with the groove in the segments of the second said series elongated whereby to allow the second said series

24

to move longitudinally in relation to the first said series, the said spring and the said terminal flange engaging at least the ends of the first said series of segments.

12. A tube expander constructed and operated substantially as described and illustrated in the accompanying specification.

1/4

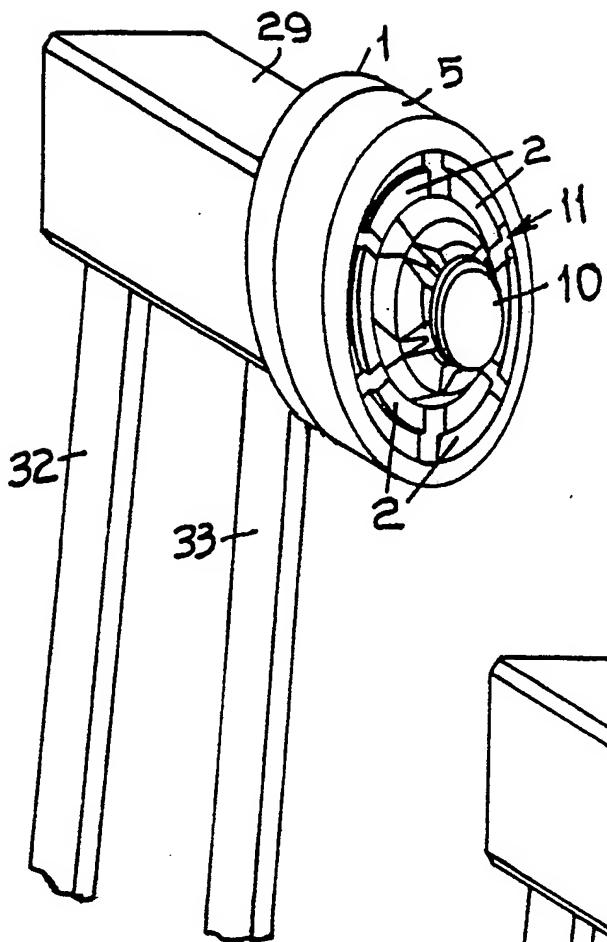


FIG. 1

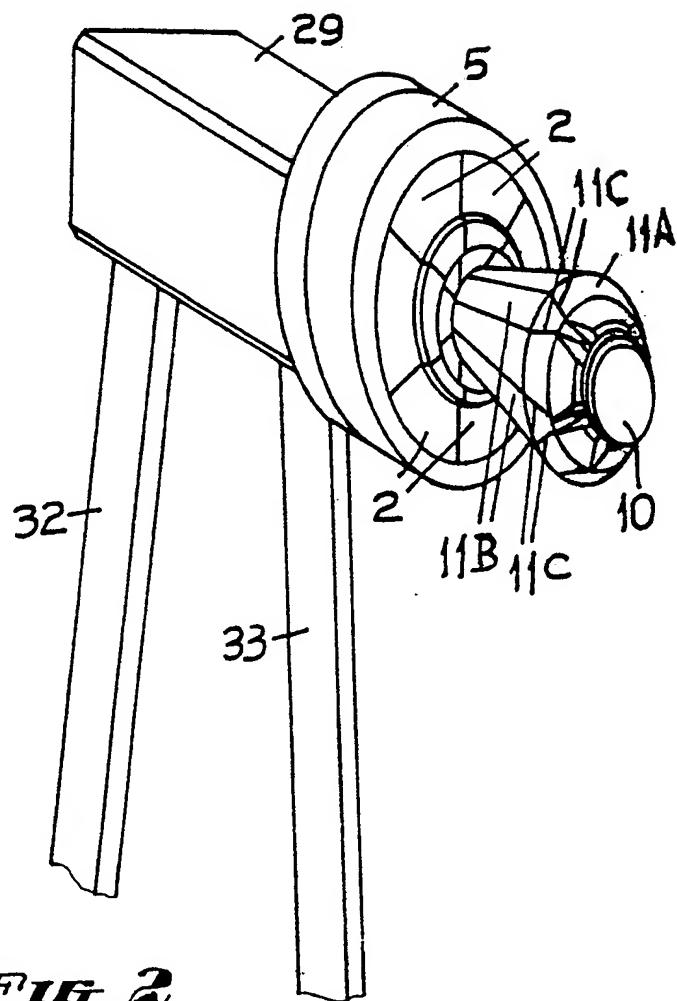
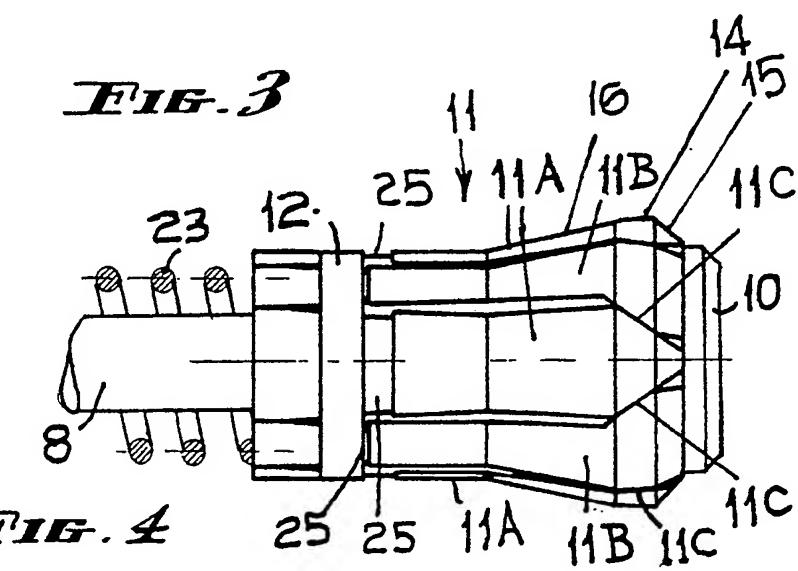
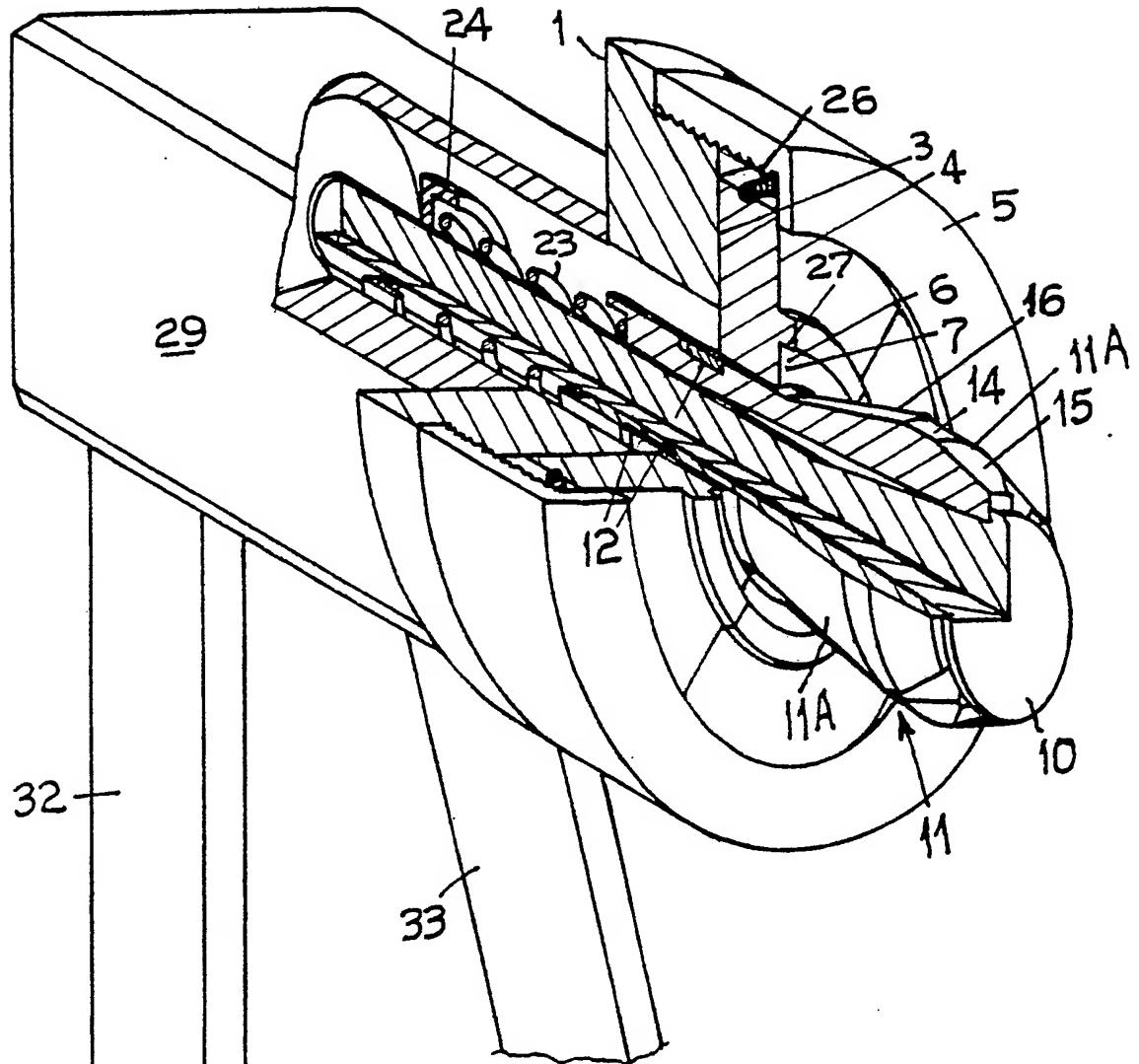
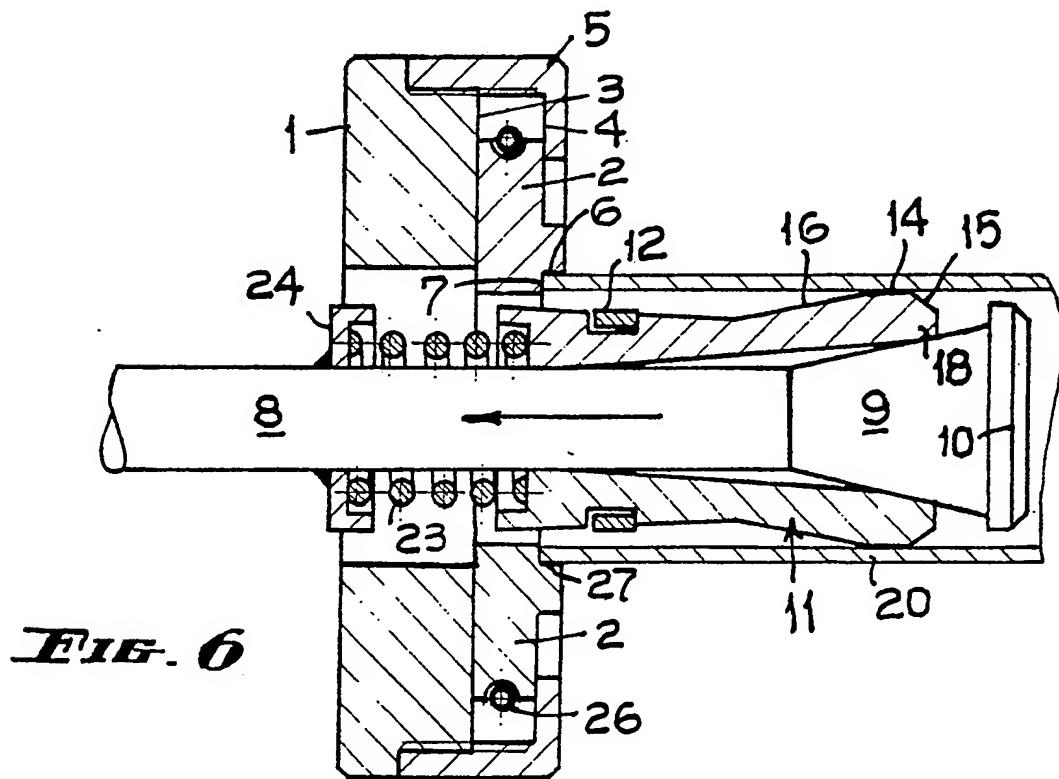
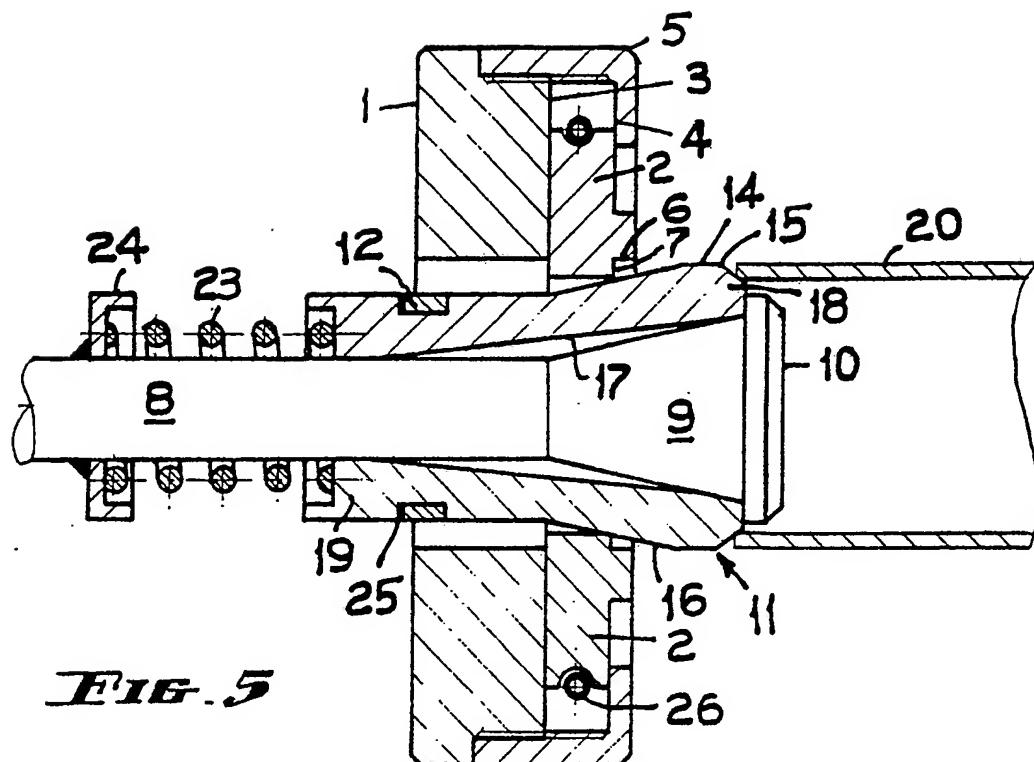


FIG. 2



3/4



4/4

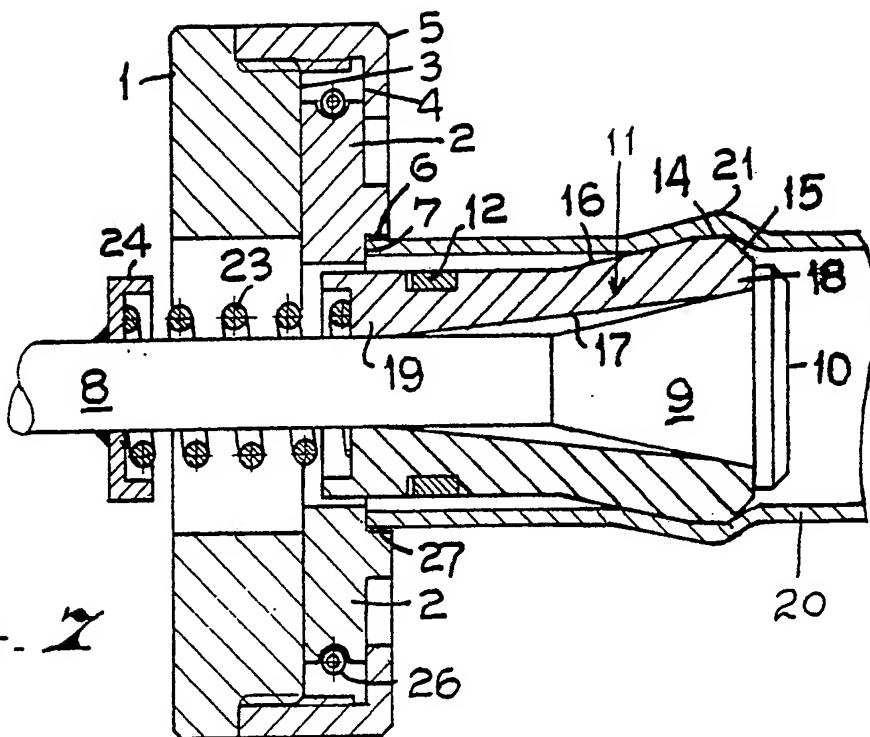


FIG. 2

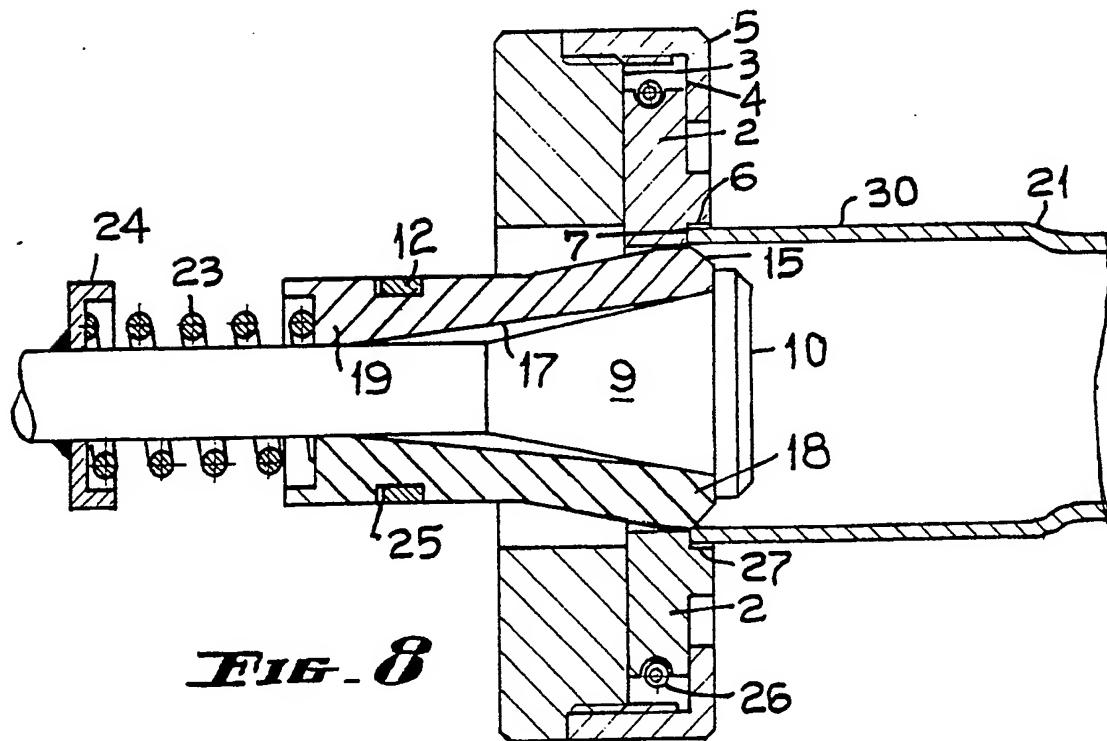


FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 83/00083

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³

According to International Patent Classification (IPC) or to both National Classification and IPC -

Int. C1 ³ B21D 41/02

II. FIELDS SEARCHED

Minimum Documentation Searched ⁴

Classification System	Classification Symbols
IPC	B21D 41/02

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched ⁵

AU; IPC as above, Australian Classification 74.613

III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴

Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
A	US,A, 3888102 (NIGIDO) 10 June 1975 (10.06.75)	
A	US,A, 4198844 (LOWE) 22 April 1980 (22.04.80)	
A	DE,A, 1944072 (van KLEEF) 12 March 1970 (12.03.70)	
A	AU,B, 47647/59 (236282) (JURY & SPIERS) 6 October 1960 (06.10.60)	
A	AU,B, 20786/62 (274307) (DEKOCK) 13 February 1964 (13.02.64)	
X	SU,A, 192159 (BUCHMAN) 13 April 1967 (13.04.67) (DERWENT ENGLISH LANGUAGE ABSTRACTS p5 1050385/25-27)	

- Special categories of cited documents: ¹⁵
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search ¹⁹

19 September 1983 (19.09.83)

International Searching Authority ²⁰

Australian Patent Office

Date of Mailing of this International Search Report ²¹

29 September 1983 (29.09.83)

Signature of Authorized Officer ²⁰

P.F. GOTHAM

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X	SU,A, 579077 (SUVRIN) 18 Nov 1977 (18.11.77) (Derwent English Language Abstract) M21 70113A/39)	(1-16)
X	SU,A, 638405 (POZHIDAEV) 28 Dec 1978 (28.12.78) (Derwent English language Abstract) P52 J1088B/38)	(1-16)
X	SU,A, 916026 (RATOVA) 30 March 1982 (30.03.82) Derwent English Language Abstract P52 11734 K/05)	(1-16)
Y	JP,A, 53-119266 (SUMITOMO KINZOKU KOGYO K.K.) 18 Oct 1978 (18.10.78) (Japatic English Language Abstract)	(1-16)

V. OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE¹⁰

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. Claim numbers _____, because they relate to subject matter¹² not required to be searched by this Authority, namely:

2. Claim numbers _____, because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out¹³, specifically:

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING¹¹

This International Searching Authority found multiple inventions in this International application as follows:

1. As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the International application.
2. As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the International application for which fees were paid, specifically claims:
3. No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- The additional search fees were accompanied by applicant's protest.
- No protest accompanied the payment of additional search fees.

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)